NASA Innovative Advanced Concepts

Seismic Exploration of Small Bodies

Completed Technology Project (2015 - 2016)

Project Introduction

We propose to examine the use of small satellites (cubesats) and a unique micro-seismometer concept developed at the Arizona State University to understand the interior structure of small bodies (asteroids and comets). The basic implementation approach would be to deploy one or more micro-seismometers on the surface of a small body and then impact the body with a projectile as an energy source. This active seismology experiment would provide the seismic velocity of the interior across some number of ray paths and thus resolve the basis question as to whether asteroids are rubble piles or have solid interiors with a fragmental surface layer. The concept could also be applied to a comet to determine if the interior structure was homogenous or if they contain a rocky interior. This implementation represents a novel approach to understanding a key science question for small bodies - their interior structure - using a new kind of instrumentation in the context of a single or multiple small (cubsat-scale) spacecraft. This implementation would present a low-risk, low-cost, high-return opportunity to understand a key question related to science, exploration and Earth-hazards.

Anticipated Benefits

This implementation represents an innova- tive approach to planetary seismology and under- standing the interior of a small body. Both the in- strument concept and the mission scenario using small satellites represent a completely different ap- proach to the problem. This approach avoids major challenges of deployment for mechanical systems, uses low-mass, low-power instrumentation, and employs small satellite technology to reduce risk and lower cost (compared with a large single mis- sion concept such as InSight). The benefits of the approach to be studied here is that it is applicable to any body in any part of the solar system. While details regarding the thermal environment and the power requirements will change depending upon the location, the basic sensor and instrument design is the same.

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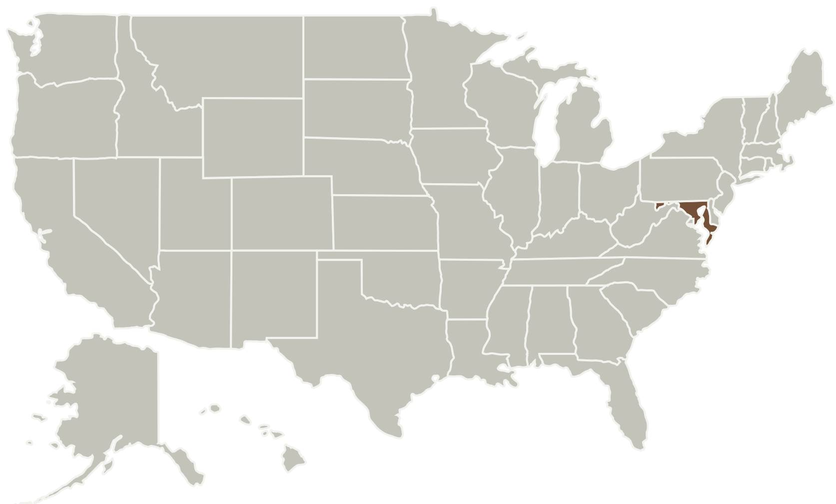
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Johns Hopkins University Applied Physics Laboratory(JHU/APL)	Lead Organization	R&D Center	Laurel, Maryland
Johns Hopkins University	Supporting Organization	Academia	Baltimore, Maryland

Primary U.S. Work Locations
Maryland

Project Transitions

July 2015: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Johns Hopkins University Applied Physics Laboratory (JHU/APL)

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

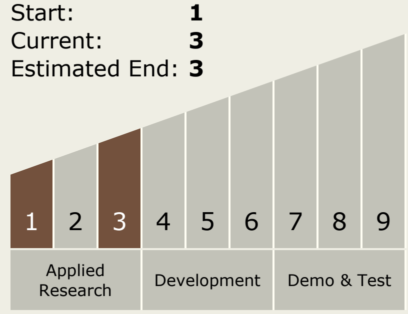
Eric A Eberly

Principal Investigator:

Jeffrey Plescia

Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **3**



June 2016: Closed out

Closeout Summary: As a result of the Phase I study, we have demonstrated th at a mission to a small body (asteroid, comet) whose objective is to conduct a s eismic experiment to understand the interior structure, can be accomplished wit h small (<200 kg) spacecraft launched on a small launch vehicle (Athena IIc). W e modeled the seismic response of a small body and calculated that the energy necessary to propagate through the body and be detected by a seismometer. Th ese calculations provide guidance as to the type of energy source that is require d. A simple energy source similar to a NASA standard initiator (NSI) can be use d, although a single NSI is insufficient. An NSI is an explosive pyrotechnic that is used to sever connections on spacecraft. Use of such an energy source has illust rated two additional areas of study - anchoring of the source and sensor to the s urface and understanding the efficiency of energy propagation from the source i nto the surface. The spacecraft has the ability to carry and deploy a series of so urce/sensors to conduct the experiment by placing them on the surface. We ide ntified a suite of candidate near-Earth asteroids as targets and used one 1991V G as the target to calculate the mission trajectory and ▲V requirements. Spacec raft and launch vehicle performance are launch that any of the candidates could be reached with appropriate mass and launch margins. Sources and sensors are deployed from arm attached to the spacecraft. The spacecraft maneuvers next t o the target body and presses the sensor against the surface and releases it. Aft er emplacing all of the surface packages, the sensors are monitored for a period of time to measure the seismic noise. Finally, the active seismic experiment is c onducted. The work conducted during Phase I demonstrates that a small missio n can be designed to conduct an active seismic experiment on a small near-Eart h body. While other targets may require more performance, the basic architectu re is viable for any target. We have identified a number of specific technical area s that require more detailed study. Those areas are largely focused on the detail ed analysis and design of the source mechanism and anchoring it to the surface. Such topics will be part of a Phase II proposal.

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Technology Areas

Primary:

- TX04 Robotic Systems
  └ TX04.2 Mobility
    └ TX04.2.2 Above-Surface Mobility

Target Destination

Outside the Solar System